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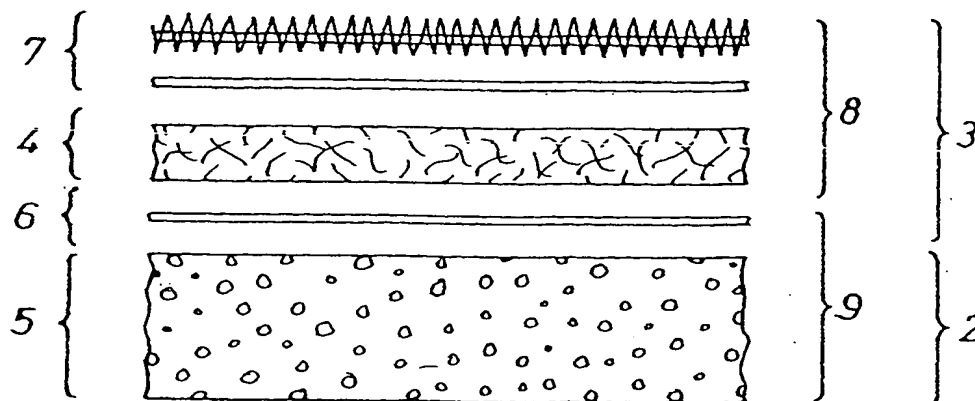
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ULTRALIGHT TRIM COMPOSITE



(57) Abstract: An ultra light, noise reducing composite (1) comprises an acoustically transparent, light weight film (6) between an underlay layer (5) and an air flow resistance layer (4). This composite allows to easily tune the acoustic properties by balancing the absorption and sound transmission behaviour of the composite (1). This air flow resistance layer (4) has an air flow resistance of between 500N s/m³ and 10'000Ns/m³ and an area mass between 200 g/m² and 3'000 g/m². The underlay layer (5) has a stiffness value in the range between 100 Pa and 100'000 Pa. The light weight film (6) may consist of a synthetic foil and preferably has a thickness of 0.01 mm.

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Therefore it is the aim of the present invention to achieve an ultralight trim composite with a structure which allows to easily tune the acoustic properties, i.e. has a high capacity for an inexpensive or low cost production of a large variety of products with a predetermined acoustic behaviour.

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This is achieved by a composite according to claim 1 and in particular by balancing the absorption and sound transmission behaviour within a product comprising a first acoustically effective layer (AFR layer) having an air flow resistance R between 500 Ns/m³ and 10'000 Ns/m³, preferably between 500 Ns/m³ and 5'000 Ns/m³, in particular between 500 Ns/m³ and 2'500 Ns/m³ and having an area mass m_A of between 200 g/m² and 3'000 g/m², in particular between 200 g/m² and 1'600 g/m². This AFR layer consists of a densified fibre felt and, in particular, comprises microfibres. Alternatively, this AFR layer may consist of perforated foils, foam, metallic foam or any other suitable materials. The sound absorption can easily be optimised by varying the thickness (0.5 – 8mm, in particular 0.5 – 6mm, preferably 2mm) or the fibrous composition of this AFR layer. The multilayer product according to the present invention further comprises a second, foam underlay, layer with a very low compression force deflection (CFD) modulus, according to ISO, DIN or ASTM standards. The stiffness S_D of this elastic second foam underlay layer acting as a decoupler has a typical value in the range of between 100Pa and 100'000Pa. This decoupler may be constituted from any suitable material, in particular a porous foam or a gel. In addition, the multilayer product according to the present invention comprises an acoustically transparent, very thin and light weight film arranged between the backing layer, i.e. the second foam underlay layer, and the first, sound absorbing AFR layer. This acoustically transparent film may consist of any thermoplastic material, in particular may consist of PVOH, PET, EVA, PE, PP foil or in particular of a PE/PA dual layer foil. This foil acts in combination with this backing layer as an acoustic foil absorber. In particular, this foil may consist of an adhesive layer or may consist of merely the skin of a foam slab. The above mentioned compression stiffness S_D of the backing layer and the thickness of this film influence the acoustic behaviour of the product according to the present invention. It is to be understood that this film can be perforated, and in particular micro-perforated, in order to increase the absorption properties or can be unperforated in order to increase the transmission loss of the composite product. This backing layer can be constituted by a backfoaming process or by attaching a foam slab with a closed or open pored skin.

35 Preferred embodiments of the present invention comprise features of the dependent claims.

Ultralight trim composite

The present invention is concerned with an ultralight trim composite for reducing noise in motor vehicles and comprises the features of the preamble of claim 1.

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Such a composite is disclosed in WO98/18656 and outlines a lightweight material configuration with material properties which provide a defined sound absorption behaviour. In particular, this absorption behaviour is controlled primarily by the area weight and air flow resistance properties of an open pored air flow resistance ("AFR") layer, as well by as the
10 thickness of a porous backing or decoupler layer. The intention of this concept is to compensate for the reduction in transmission loss of the composite (caused by its reduced weight as compared to a conventional mass-barrier insulation system), with a well defined sound absorption behaviour.

15 The original industrialisation of this concept, where resonated fibre layers were used for both the AFR layer and the porous backing layer has proven to be successful. As development work continues to improve the success of this concept with other materials such as polyurethane foams, difficulties have been encountered in defining cost-effective processes to produce components which follow the guidelines of the above mentioned patent.

20 Specifically, when backfoaming directly to a fibrous AFR layer, the foam chemicals saturate the fibres and effectively close pores of the AFR layer, resulting in poorly absorbing configurations with high air flow resistance values lying outside the target range of the teaching of the above publication.

25 Similar multilayer light weight products are already known in the art and disclosed in EP-B-0'384'420 for instance. The product according to this disclosure comprises an acoustically effective layer, which consists of a combination of two layers: at least one porous synthetic layer with an area mass from 150 g/m² to 1500 g/m² and one fleece layer with an area mass from approximately 50 g/m² to 300 g/m². This fleece layer is backfoamed or is covered with
30 a dense foil and/or a heavy layer before backfoaming. This document is silent about the air flow resistance or the thickness of the acoustically effective layer, both parameters being relevant for optimising the acoustic behaviour of trim products.

All these known light weight products are rather difficult to manufacture and therefore cause
35 high production costs when adapting these products to different purposes or applications which require slightly changed acoustic properties.

The advantages of the present invention are obvious to the man skilled in the art. Dependent upon the desired acoustic behaviour, it is easily and cost-effectively possible to assemble a corresponding product, by varying the AFR value of the first layer, by varying the amount and size of perforations in the film, and/or by varying the structure of the foam surface.

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In addition this composite allows to easily separate the foam parts from the fibre felt parts during recycling.

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In the following the viability of the present ultra light composite configuration, providing easily tunable sound absorption and transmission loss behaviour is discussed.

Fig. 1: shows a schematic view of a composite assembly according to the invention;

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Fig. 2: shows a diagram representing an absorption and sound transmission loss behaviour of a typical composite according to the invention.

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The ultralight trim composite 1 of the present invention comprises a combination of layers which primarily behave like an acoustic spring-mass-system, i.e. comprises at least one layer acting as a spring 2 and at least a sound absorbing AFR layer 4 acting as mass 3 of the acoustic spring-mass-system. This sound sound absorbing AFR layer 4 preferably consists of fibres or a combination of fibres and chipped foam.

25

The primary features of this composite are an acoustically transparent (acoustically invisible) thin film 6 present between a foam layer 5 and the AFR layer 4, which film prevents foam saturation in the fibres of the AFR layer. The soft foam backing layer 5 preferably has compression stiffness properties similar to those of the AFR layer 4. This composite may comprise further layers such as a decor or carpet layer 7, which are considered to be part of the air flow resistance absorption layer 8.

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Due to the limitations of current process technology, direct foaming to a fibrous AFR layer 4 results in foam chemicals saturating the fibres of the AFR layer 4. This then closes the AFR layer 4, resulting in very high levels of airflow resistance and a corresponding degradation of the absorption performance of the composite.

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To prevent saturation of the AFR layer fibres, an acoustically transparent, preferably non-porous, thin film 6 may be inserted between the AFR layer 4 and the foam 5 in the production process. One may clearly see that films 6 with thickness values of approximately 0.01 mm or

less have negligible transmission loss behaviour, and are to be considered as acoustically transparent. Then when this type of film 6 is combined with an ultra light composite according to WO 98/18656, it allows a sufficient part of the incoming acoustic wave to pass through and be dissipated in the porous backing layer. The end result is a slight degradation of the absorption performance of the composite.

The normal incidence sound absorption behaviour of a 25 mm foam backing layer, and of a foam backing layer with 0.0125 mm film has been simulated and compared with impedance tube measurements. Then, the validated simulation models of the foam and film are used to define the properties of the film layer inserted between the AFR and foam backing layers, ensuring the best possible absorption behaviour for the composite.

The sound absorption of such a composite (with film) was simulated for film thickness values of 1 mm, 0.1 mm, 0.01 mm and 0.001 mm respectively. The case with 1 mm film offers generally poor absorption performance, while the results show that only small improvements may be achieved using films of less than 0.01 mm thickness.

The sound transmission behaviour of such a composite with varying film thickness values were measured. In the case of the 0.091 mm film, a slight reduction in transmission loss (TL) occurred in the low frequencies as compared to a non-film configuration, but beyond 300 Hz, an overall improvement of approx. 2 - 3 dB was observed. The reduction of TL in the lower frequencies is not a great cause of concern in automotive applications, since for these frequencies structure-borne noise is of more importance than airborne-noise, and the TL of the composite does not contribute significantly for this type of excitation.

To summarize, a critical dimension of the film is that the thickness should be approximately 0.01 mm to ensure a sufficient balance between absorption and sound transmission for such a composite. Any degradation in the absorption behaviour of such composite (with film) can be compensated for by a slight increase in sound transmission performance.

Along with specifying the thickness of the non-porous film, the compression stiffness of the foam backing 5 can also be defined to ensure that the present composite has similar sound transmission behaviour as known composites.

In particular, present lightweight configurations are more sensitive to the compression stiffness of the porous backing layer than conventional mass-based systems. This was shown when the simulated sound transmission loss of a known composite, along with

configurations where the stiffness of the foam backing had been increased by factors of 5, 10 and 20. It can clearly be seen that increasing the stiffness of the backing layer shifts the sandwich resonance of the composite to higher frequencies. The risk then is that the sandwich resonance will coincide with localized panel vibrations in the vehicle, creating an effective noise radiator or transmitter.

Therefore, for systems with equivalent thickness and weight, the compression stiffness of the foam used in the foam backing according to the invention should be similar to the resonated felt backing in known assemblies in order to ensure that the present composite has a similar sound transmission behaviour.

This was shown by another measurement, where the Load - Force - Deflection (LFD) for 25 mm thickness samples of resonated felt and foam backing according to the invention have been measured. These curves express how the material stiffness changes with deformation. From this information, the material compression stiffness can be derived from the slope of the curve in the fully relaxed linear elastic region (less than 5% strain or deformation). The slopes are similar for both the foam and resonated felt layers, indicating that both materials have comparable compression stiffness values, i.e. have similar sound transmission loss performance.

The primary acoustic characteristic of the foam layer according to the invention is that it is soft in compression stiffness (the reason for its effectiveness as part of an ultralight composite), more so than typical polyurethane foams (PU), and comparable to so-called heavier viscoelastic foams.

Transmissivity (transmissibility) information (the ratio of motion at the top of the multilayer composite to the bottom of the composite) can be used to emphasize this statement further. The simulated transmissivity of a composite according to the invention, along with configurations where the stiffness of the foam backing has been decreased by a factor of 0.5, and increased by factors 5, 10 and 20 have been determined. In these measurements, the frequency of the sandwich resonance is clearly highlighted, along with other material resonances at occurring higher frequencies. As expected, for configurations with lightweight AFR layers, the use of a compressionally soft foam backing layer is effective at moving the sandwich resonance of the ultra light composite below the sensitive 400 Hz - 1000 Hz frequency range. The performance of the composite then can be improved by reducing the stiffness of the backing layer even further, which can be achieved through the choice of foaming ingredients and processing methods.

Finally, a set of specifications for the range of allowable stiffness values of the foam backing according to the invention for given AFR layer weights, can be derived from the average transmissivity contour. Here, the transmissivity of UL composites with a 2 mm AFR layer, and 25 mm porous backing layer has been calculated and averaged over 3rd octave frequency bands (10 Hz - 2000 Hz) for varying AFR layer weights and backing layer compression stiffness values.

Using this information, the following general specifications for an ultra light composite may be given: AFR layer area weight greater than 0.2 kg/m², foam compression stiffness less than 50'000 Pa (currently used foams and a typical resonated felt pad have stiffness values of approx. 20'000 Pa).

As was described earlier, direct backfoaming to an AFR fibre layer seals the layer and causes a noticeable degradation in the absorption performance of the composite. By implementing a thin film between the AFR and foam layers, and by using a compressionally soft foam backing, the acoustic performance of a composite according to the invention can have the similar balance between absorption and sound transmission as conventional composites (spring-mass-systems having a heavy layer) with slightly reduced absorption and slightly improved sound transmission behaviour.

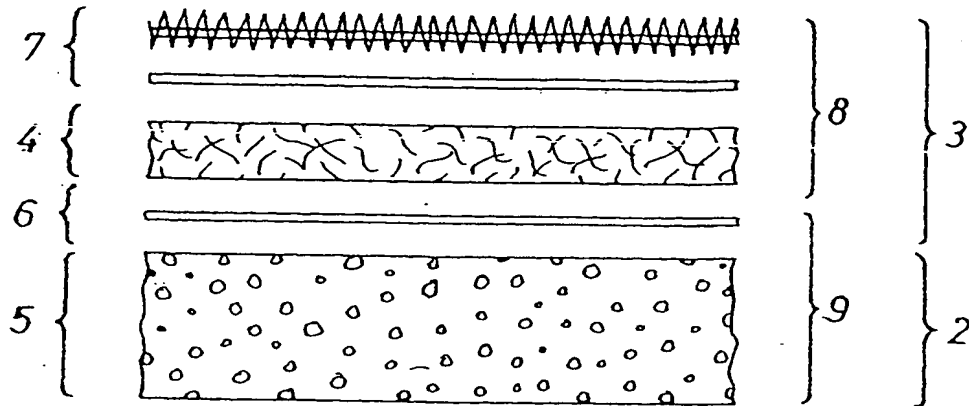
The acoustic behaviour of the present composite, as shown in Figure 2, can easily be tuned, in particular by perforating the film 6 of the present composite 1, taking into consideration that the backing foam layer 5 and the film 6 may interact with each other in the manner of an acoustic foil absorber 9. Based on this concept it could be advantageous to use a perforated foil 6 and/or to use a foam slab 5 with or without an open pored skin. It is understood that the man skilled in the art can use a foam with open or closed cells. Investigations have shown that the absorption performance increases at lower frequencies when using foam slabs with increased skin weight. Using an open pored skin increases the absorption performance at higher frequency regions.

Of course, the composite according to the invention can be used not only in the automotive field but also in any technical fields where sound reducing panels are used, such as building constructions, in the machine industry, or in any transportation vehicles.

Patent Claims:

1. An ultralight trim composite (1) comprising a first acoustically effective layer (4) and a second underlay layer (5), characterised in that for the balancing of the absorption and sound transmission behaviour of the composite, the first acoustically effective layer (4) has an air flow resistance R between 500 Ns/m³ and 10'000 Ns/m³ and has an area mass m_A between 200 g/m² and 3'000 g/m², the second underlay layer (5) has a very low compression force deflection modulus, i.e. a stiffness value S_D in the range between 100Pa and 100'000Pa and in addition comprises an acoustically transparent, very thin and light weight film (6) between the second underlay layer (5) and the first acoustically effective layer (4), which film interacts with this underlay layer (5) in the manner of an acoustic foil absorber (9).
2. Composite according to claim 1, wherein the second underlay layer (5) is a backfoamed layer.
3. Composite according to claim 1, wherein the second foam underlay layer (5) consists of a foam slab.
4. Composite according to claim 3, wherein the foam slab comprises an open pored skin.
5. Composite according to claim 1, wherein the film (6) is perforated in order to increase the absorption properties.
6. Composite according to claim 5, wherein the film (6) is microperforated.
7. Composite according to claim 1, wherein the film (6) is unperforated in order to increase the transmission loss.
8. Composite according to one of the previous claims, wherein the first acoustically effective layer (4) has a thickness of 0.5 mm to 8.0 mm
9. Composite according to claim 8, wherein the first acoustically effective layer (4) has an area weight of about 1 kg/m².

10. Composite according to one of the previous claims, wherein the second foam underlay layer (5) acting as a decoupler layer, has a thickness of about 20mm.
11. Composite according to claim 1, wherein the film layer has a thickness of about 0.01 to 1.0 mm

$1/2$ *Fig. 1*

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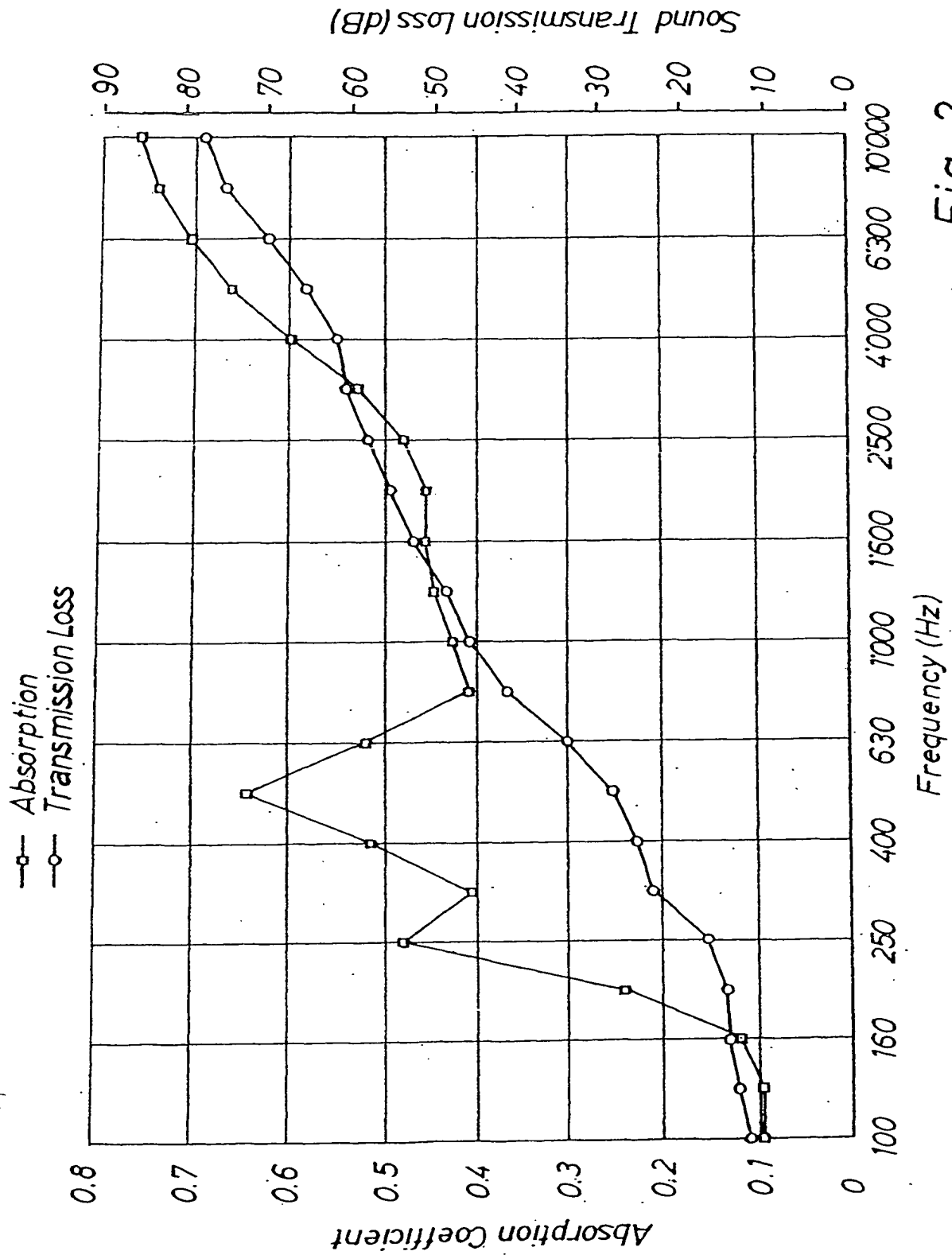
$2/2$ 

Fig. 2

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International No

PCT/EP 03/13870

| Patent document cited in search report | | Publication date | Patent family member(s) | Publication date |
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP 03/13870

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 1-11, in part
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the trim composite comprising a first layer made from a fibrous layer, a second foam underlay, and an acoustically transparent film made from PVOH, PET, EVA, PE, PP foils or a PE/PA dual foil as disclosed in the description on page 2, lines 23-25, and page 3, lines 20-25.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 1-11, in part

Present claim 1 relates to an "ultralight trim composite, comprising a first acoustically effective layer and a second underlay layer, characterised in that, for the balancing of the absorption and sound transmission behaviour of the composite, the first acoustically effective layer has an air flow resistance R between 500 and 10.000 Ns/m^3 , and has an area mass between 200 and 3.000 g/m^2 ; the second underlay layer has a very low compression force deflection modulus, i.e. a stiffness value S_d in the range between 100 and 100.000 Pa ; and, in addition, comprises an acoustically transparent, very thin and light weight film between the second underlay layer and the first acoustically effective layer, which film interacts with this underlay layer in the manner of an acoustic foil absorber".

In view of this wording, several objections under Art.5 and 6 PCT arise to such an extent that they render a meaningful search of said claim 1 impossible. The reasons are the following:

- (i) Present claim 1 does not refer to the materials constituting the trim composite, but instead is only defined by ranges of values for certain properties or test results. In fact, it relates to a product defined only by reference to desirable characteristics or properties such as the air flow resistance and area mass of the first layer and the stiffness value of the second underlay layer. Thus, it covers all products having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and disclosure within the meaning of Article 5 PCT for only a very limited number of such products; at present, the features responsible for the desired properties, i.e. the essential features, do not appear in said claim. Thus, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible.
- (ii) Besides, the use of the compression force deflection modulus parameter in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameter the applicant has chosen to employ with what is set out in the prior art.
- (iii) Independent of the above reasoning, claim 1 also lacks clarity (Article 6 PCT) in that an attempt is made to define the product by reference to several results to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible.
- (iv) At last, claim 1 defines the trim laminate using many vague terms and expressions, such as "ultralight", "acoustically effective", "very low", "very thin", "light weight", "interacts with this underlay in the manner of an acoustic foil absorber", by reference to a desirable characteristic or property. These terms have either a relative or a very broad meaning, and can in any case not be used to distinguish the present invention over the prior art. Thus, they lead to a lack of clarity within the meaning of Art.6 PCT.

INTERNATIONAL SEARCH REPORT

International Application No.
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|--|-----------------------|
| A | <p>WO 99/35007 A (RIETER AUTOMOTIVE INT AG ; ALTS THORSTEN (DE)) 15 July 1999 (1999-07-15) claims 1-3,16,17 page 6, line 1 - page 7, line 19 _____</p> | 1 |

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP 03/13870

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G10K11/168

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|---|-----------------------|
| X | WO 98/18656 A (RIETER AUTOMOTIVE INT AG ; ALTS THORSTEN (DE)) 7 May 1998 (1998-05-07) cited in the application claim 1 page 6, line 5 - line 37 figure 4 | 1-11 |
| X | WO 02/094616 A (RIETER TECHNOLOGIES AG ; O'REGAN DESMOND (GB); KHAN HAMEED S (US); FIS) 28 November 2002 (2002-11-28) claims 1,3-5 page 3, line 11 - line 22 page 4, line 1 - line 6 tables 1,2 | 1-6,8-11 |

-/--

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

31 March 2004

Date of mailing of the international search report

06/04/2004

Name and mailing address of the ISA

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Girard, S